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STATIC TEST OF THE AEROMARINE PG-1 AIRPLANE

(AIRPLANE SECTION S. & A. BRANCH)

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McCook Field, Dayton, Ohio
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CERTIFICATE: By direction of the Secretary of War the matter contained herein is published as administrative information and is required for the proper transaction of the public business.

STATIC TEST OF THE AEROMARINE PG-1 AIRPLANE.

SUMMARY OF RESULTS.

Airplane: Aeromarine PG-1
Type: Biplane.
Total weight: 3,918 pounds.
Wing cellule weight: 668 pounds.
Wing area: 393 square feet.
Engine: Wright, 350 horsepower.

Description: The PG-1 airplane is a biplane with an armored fuselage. The 8-cylinder Wright engine mounts a 37-mm. cannon. The wings are of wood construction, while the tail surfaces and fuselage are of steel construction. Fabric is used for covering.

Results of test.

Date.	Part tested.	Load required.	Pounds per square foot or factor supported.	Failed at—	Weight.	Failure.
1921. Dec. 6	Horizontal stabilizer.	30 pounds per square foot.	15 pounds per square foot.	20 pounds per square foot.	1.7 pounds per square foot.	Rear spar failed in bending.
Do..	Elevator	do	20 pounds per square foot.		1.26 pounds per square foot.	Elevator and elevator controls were not given the required loading due to early stabilizer failure.
Do..	Elevator control.	6	5			
Do..	Vertical fin	25 pounds per square foot.	25 pounds per square foot.		1.29 pounds per square foot.	Fin is satisfactory structurally.
Do..	Rudder	do	do		1.16 pounds per square foot.	Rudder is satisfactory structurally.
Do..	Rudder control	5	2	3		Rudder pedal failed by twisting.
Dec. 7	Ailerons	25 pounds per square foot.	25 pounds per square foot.		0.918 pound per square foot.	Aileron satisfactory structurally. Failure of bell crank in wing cellule by twisting.
Do..	Aileron control	5	3	4		
	Wing cellule:					
Dec. 14	High incidence.	Factor 7	6	6.5	1.71 pounds per square foot.	Right upper front spar failed at load factor of 6.5.
Dec. 12	Low incidence	4.5	4.5			Wing cellule unsatisfactory structurally.
Dec. 8	Reverse load	3	3			Do.
1922. Jan. 9	Six foot length of leading edge.	14	15	16.32		Leading edge satisfactory structurally.
1921. Dec. 20	Fuselage	6	6.5	7	832.5 pounds	For bending test, fuselage satisfactory structurally.
1922. Mar. 4	Tail skid	36-inch drop	18-inch drop	24-inch drop		For impact test, rear part of fuselage is structurally weak.
1921. Dec. 23	Chassis:					
	Strut	6	5		71 pounds less wheels.	With recommended changes the landing chassis is structurally satisfactory.
	Axle	5.5	5			
	Shock absorber	5	4.5	5		

Weight of 2 wheels = 52 pounds.

DISCUSSION.

Due to the fact that the rear stabilizer spar failed at less than the required load, it was impossible to test the elevator controls up to the required load factor. Likewise, the landing chassis shock-absorber fitting failure prohibited the testing to destruction of the axle and struts.

OBJECT.

This static test was conducted for the purpose of determining the structural strength of the Aeromarine PG-1 airplane submitted in accordance with contract No. 354, dated March 15, 1921..

This airplane was designed at McCook Field, Dayton, Ohio, and built by the Aeromarine Corporation of Keyport, N. J., and bore the Air Service No. 64244.

DATE AND PLACE.

The following-named parts were all tested at McCook Field, Dayton, Ohio, on dates mentioned below:

1. Dec. 6, 1921........Elevator and stabilizer.
2. Dec. 6, 1921........Rudder and fin.
3. Dec. 7, 1921........Ailerons.
4. Dec. 8, 1921........Wing cellule (reverse flight).
5. Dec. 12, 1921........Wing cellule (low incidence).
6. Dec. 14, 1921........Wing cellule (high incidence).
7. Dec. 20, 1921........Fuselage.
8. Dec. 23, 1921........Chassis.
9. Jan. 9, 1922........Leading edge test.
10. Mar. 31, 1922........Tail skid test.

WITNESSES.

Lieut. C. N. Monteith...Tests Nos. 1, 2, 3, 4, 5, 6.
Lieut. E. W. Dichman...Tests Nos. 1, 2, 3, 4, 5, 6, 7, 8.
I. M. Laddon...........Tests Nos. 1, 4, 5, 6, 7.
Ray Whitman...........Tests Nos. 1, 2, 4, 5, 6, 7.
W. E. Savage...........Tests Nos. 1, 2, 3, 4, 5, 6, 7, 9, 10.
D. B. Weaver...........Tests Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9.

SUMMARY.

WING CELLULE.

Static test loading schedules were based on a total weight of 3,918 pounds and a wing weight of 610 pounds.

REVERSE LOADING TEST.

Load factor required, 3.

Inclination of wing chord 14° from horizontal, with trailing edge down. The center of gravity of load was a distance back from the leading edge equal to 25 per cent of wing chord on both upper and lower wings. Load carried to a factor of 3 without failure.

LOW INCIDENCE LOADING.

Load factor required, 4.5.

Inclination of wing chord was 7° 7′ with trailing edge of wing down. The center of gravity of the load was a distance from the leading edge of the wing equal to 46 per cent of the chord. Load carried to a load factor of 4.5, but at load factor of 3.5 the lower wing commenced to tilt backward severely.

HIGH INCIDENCE LOADING.

Load factor required, 7.

The center of gravity of the load was a distance from the leading edge of the wing equal to 31 per cent of the chord. The angle of inclination was 7° 54′, leading edge down. With a load equal to a factor of 5 the compression tube in the upper front spar deflected severely and was braced to continue the test. The right upper front strut fitting failed in bending with a load equal to a factor of 6.5.

Aileron load required, 25 pounds per square foot. Surfaces held satisfactorily.

ELEVATORS AND STABILIZER.

Load required, 30 pounds per square foot.

Load carried to 20 pounds per square foot when rear spar of stabilizer failed in bending.

RUDDER AND FIN.

Load required, 25 pounds per square foot.

Load carried to 27.5 pounds per square foot without failure to surfaces, but controls failed at 15 pounds per square foot.

FUSELAGE.

Load factor required, 6.

Load carried to a factor of 7 when failure occurred.

LANDING GEAR.

Load factor required, 6.

Load carried to a factor of 5 for one minute when the right shock-absorber fitting failed. The two five-sixteenths-inch cap screws at the ends of the shock-absorber fitting failed by shearing, while the center three-eighths inch screws pulled through the lower part of the fitting. The struts and axle withstood loading.

GENERAL RECOMMENDATIONS.

WINGS.

Redesign strut fitting.

Laminations in interplane struts to be arranged so that no two splices occur closer than 1 inch apart.

Insert three-sixteenths-inch inside diameter, one-fourth-inch outside diameter, steel spacer tubes where bolts pass through interplane struts.

Redesign upper front spar compression tube to prevent severe deflection.

Redesign aileron push rod and bell crank to withstand a load of 25 pounds per square foot on aileron.

Substitute standard shear bolts and nuts for clevice pins on all cable terminals.

STABILIZER AND ELEVATOR.

Simplify and make more accessible the rear stabilizer spar anchorage.

Redesign stabilizer rear spar to eliminate failure in bending.

RUDDER AND FIN.

Eliminate conical supports for foot pedals and substitute brackets attached to inclined baffle plate.

FUSELAGE.

None.

LANDING GEAR.

Shock absorber and fittings should be redesigned to withstand a load equivalent to a factor of 6, the required load factor for the struts.

GENERAL DESCRIPTION.

The PG-1 airplane is a single-seater armored biplane, with an 8-cylinder 350 horsepower Wright geared engine, on which is mounted a 37-m.m. cannon, which shoots through the propeller hub.

Specified performance, 125 miles per hour at ground.
Climb not important.
Ceiling not important.
Total weight, 3,818 pounds.
Useful load, 810 pounds.
Wing area, 389.30 square feet.
Weight per square foot, 10.12 pounds.
Weight per horsepower, 13.13 pounds.
Aerofoil U. S. A.-15 upper wing.
Aerofoil U. S. A.-27 lower wing.

List of equipment may be seen in section 5 of Specification 1521-A.

Figure 1 is a plan view of the PG-1 airplane.

Figure 2 shows front and side views.

WING CELLULE.

DESCRIPTION.

The wing cellule is of wood construction with box-type spars. There are two spars in the upper wing panel which has a 100-inch chord and one spar in the lower panel which has a 35-inch chord.

The main spar members are spruce, routed so as to make an I beam. Two of these I beams are joined at top and bottom by plywood one-eighth-inch thick, thus forming a box spar.

Aerofoil U. S. A.–15 is used for the upper wing and the lower wing U. S. A.–27 section.

The ribs of these wing panels are made of plywood, 3-ply Spanish cedar with poplar core and spruce cap strips.

Figure 3 is an assembly drawing of the upper wing panel.

Figure 4 is an assembly drawing of the lower wing panel.

Figure 5 shows an interplane strut and typical sections.

PROCEDURE FOR TEST (REVERSED FLIGHT).

The airplane was assembled and set in its normal position (right side up), the wing chord making an angle of 14° to the horizontal.

The center of gravity of the load on the wings was placed at 25 per cent of the wing chord from the leading edge.

The wings were then loaded in accordance with the loading schedule in Figure 6.

RESULTS.

The required load factor for a reverse flight test on wings of an airplane of this type is 3. The wings supported a load factor of 3 without any failure.

Figure 7 is a table of the spar deflections of the lower wing.

Figure 8 is a chart of the deflection curves.

PROCEDURE FOR TEST (LOW INCIDENCE).

The airplane was reset in an inverted position and loaded according to the loading schedule in Figure 9.

The angle of inclination of the wing chord to the horizontal (angle γ) was $7°-7'$, trailing edge down. This was determined from the high-speed angle of incidence α and the angle β between the lift and the resultant air force.

$$\alpha=-1°$$
$$\beta=6°-7'$$
$$\gamma=\beta-\alpha=6°-7'-(-1°)=7°-7'$$

The center of gravity of the load was located at 46 per cent of the wing chord, which corresponds to the position of the center of pressure of the wing at high speed.

The wings on this test were required to support a load factor of 4.5.

RESULTS.

No failures occurred during this test, but the lower wing tilted backward and downward on the strut fittings and deflected badly while supporting a load factor of 3.5. The wing structure supported the required load factor of 4.5.

Figure 10 is a table of spar deflections.

Figure 11 is a chart of the deflection curves.

DISCUSSION.

The tilting of the lower wing was due primarily to the fact that this wing has only one box-type spar and the bearings on the bottom of the interplane struts are insufficient to prevent rotation of the wing panels at these points.

CONCLUSION.

The wing structure supported the required loading.

RECOMMENDATIONS.

Redesign strut fittings at bottom of struts, so as to give more bearing on the wing spar. This will prevent the wing panel from twisting about these points.

PROCEDURE FOR TEST (HIGH INCIDENCE).

The airplane was reset and the wings loaded in acordance with the loading schedule in Figure 12.

The angle of inclination (γ) of the wing chord with the horizontal was $-7°-54'$, leading edge down. This was determined from the angle where the center of pressure is farthest forward, α, and β, the angle between the lift and the resultant air force.

$$\alpha=15°$$
$$\beta=\mathrm{L/D}\ \cot^{-1} 8.03=7°-6'$$
$$\gamma=\beta-\alpha=7°-6'-(15°)=-7°-54'$$

The location of the center of gravity of the load was 31.125 inches from the leading edge, which corresponds to the location of the center of pressure on the wing at $\alpha=+15°$.

RESULTS.

Figure 13 is a table of spar deflections.

Figure 14 is a chart of deflection curves.

Figures 32 and 33 are photographs of the right upper front spar fitting and spar failures.

DISCUSSION.

The load factor required is 7. At a load factor of 5 the compression tube in the center section of the upper front spar deflected severely and had to be braced before the test could be continued.

The right upper front strut fitting failed in bending while the structure was supporting a load factor of 6.5.

CONCLUSION.

The upper front spar fittings are too weak to support the required load. The front spar compression tube in the center section should be heavier.

From the examination and tests of the wing spars made by the Material Section, the following information was obtained:

Right upper front (double) wing beam, front and rear members, slightly lower in specific gravity than that for average grade of spruce, good strength properties.

Right upper rear (double) wing beam and front and rear members gave slightly lower specific gravity and strength properties than those for average grade of spruce.

Right lower (double) wing beam and front and rear members compared favorably in strength properties with those for average grade of spruce.

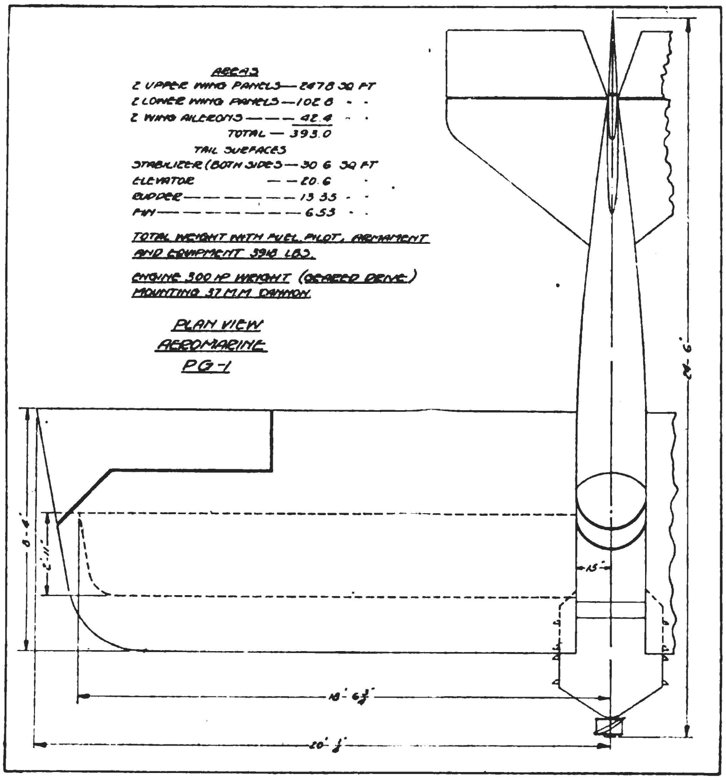


FIG. 1.—Plan view of airplane.

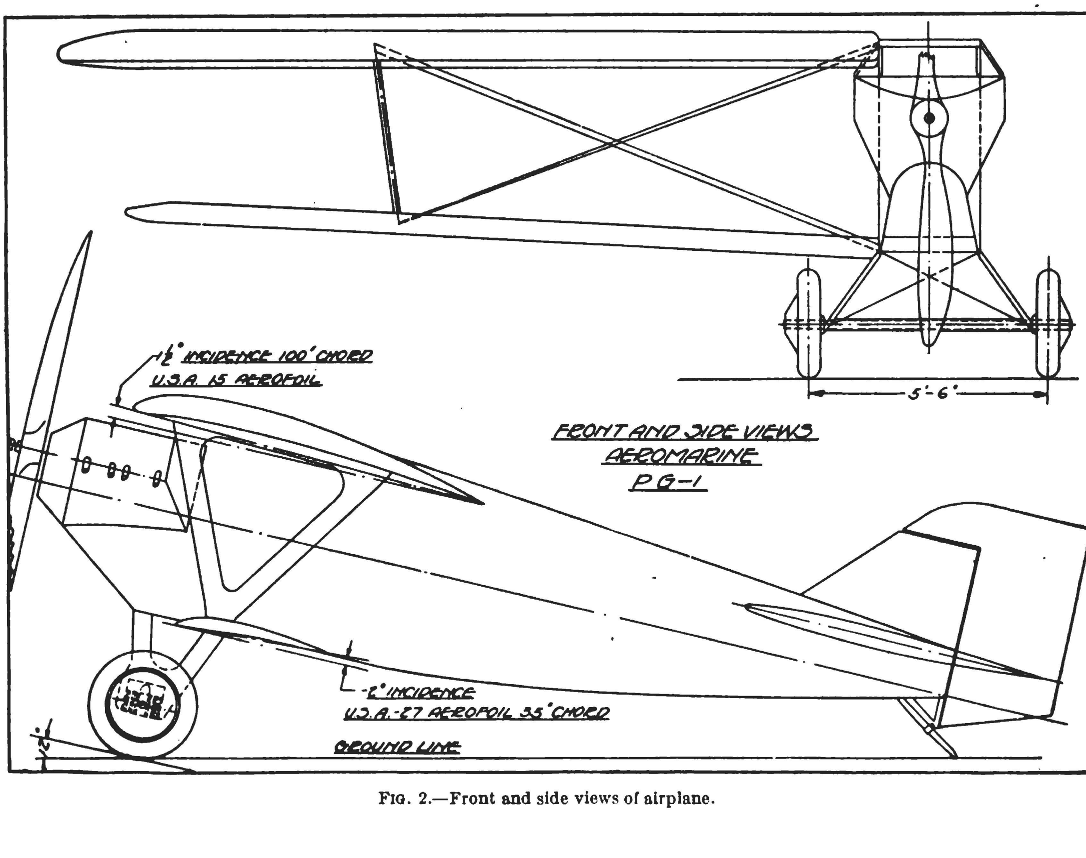


FIG. 2.—Front and side views of airplane.

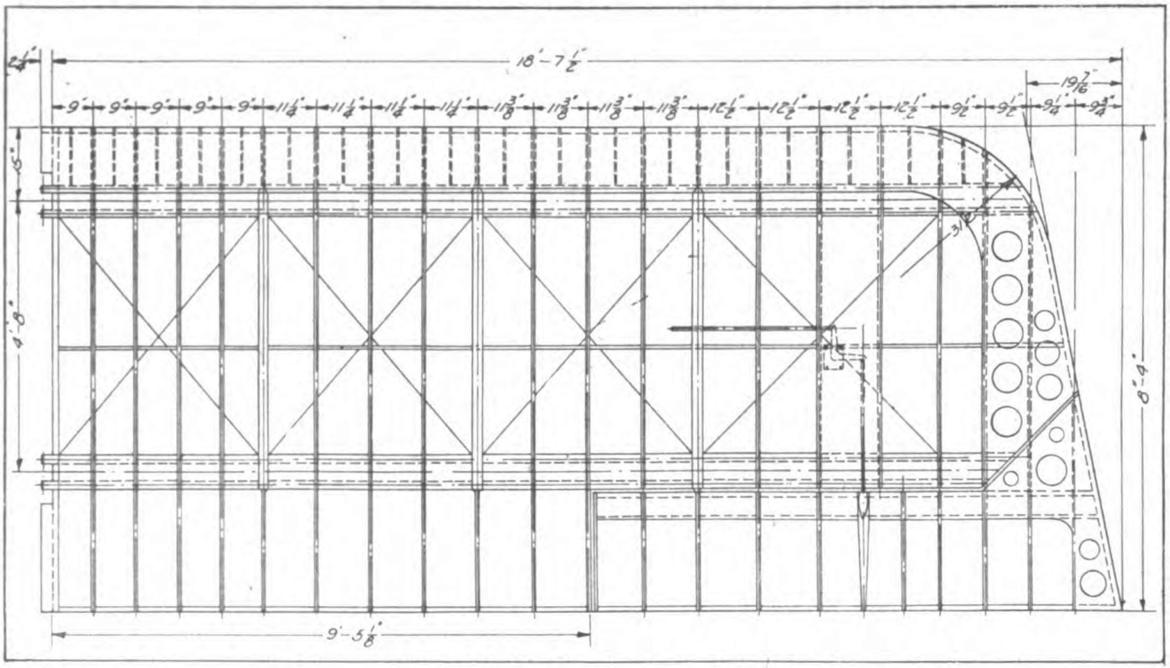


FIG. 3.—Assembly drawing (upper wing).

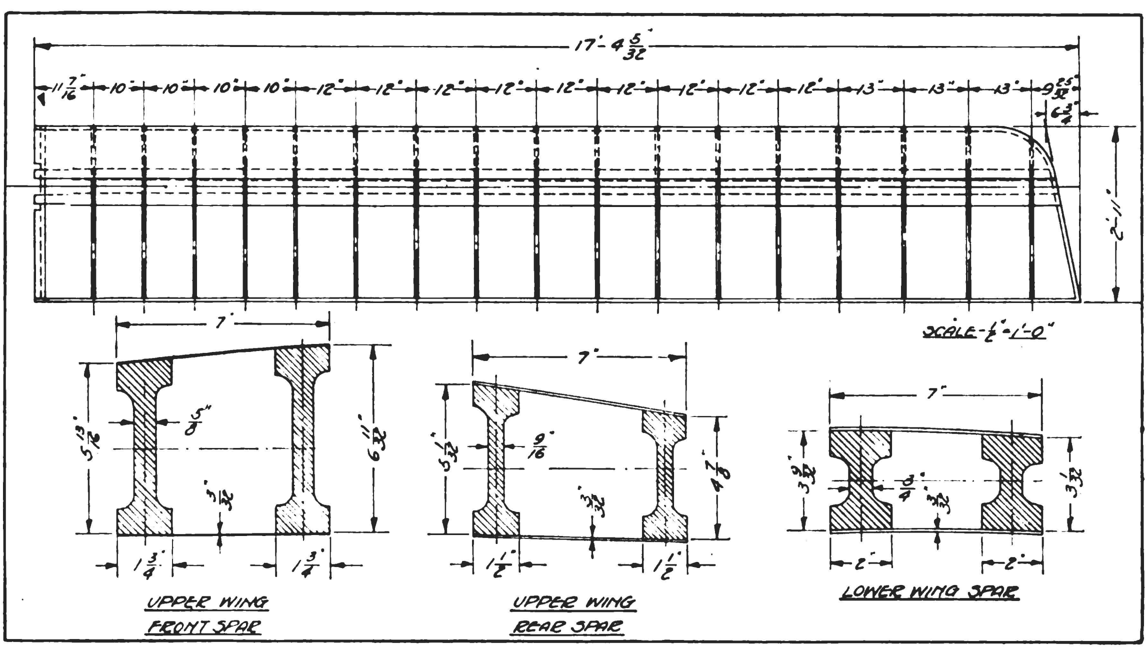


FIG. 4.—Assembly drawing (lower wing).

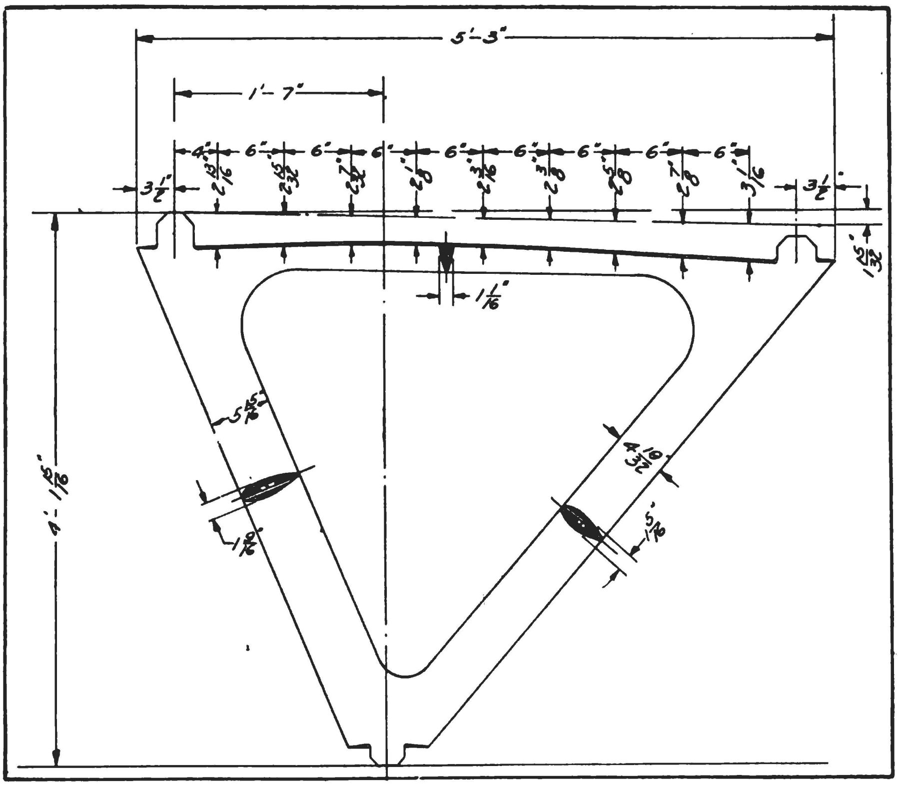
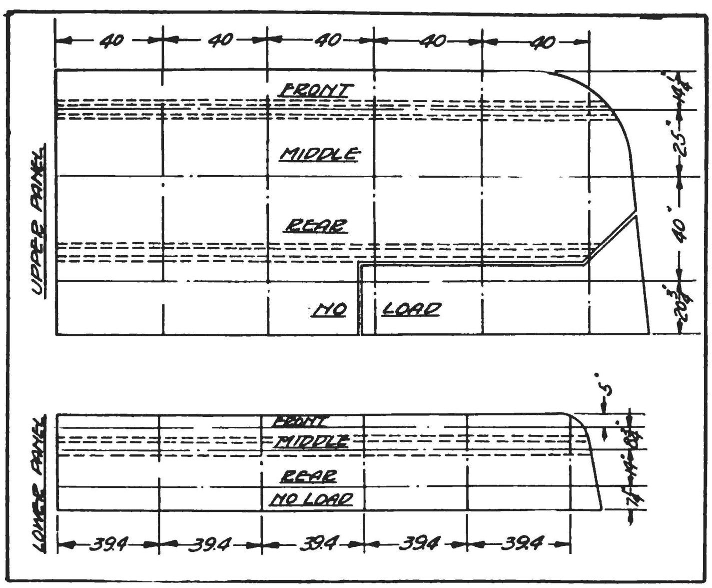


Fig. 5.—Drawing of V-strut and sections.

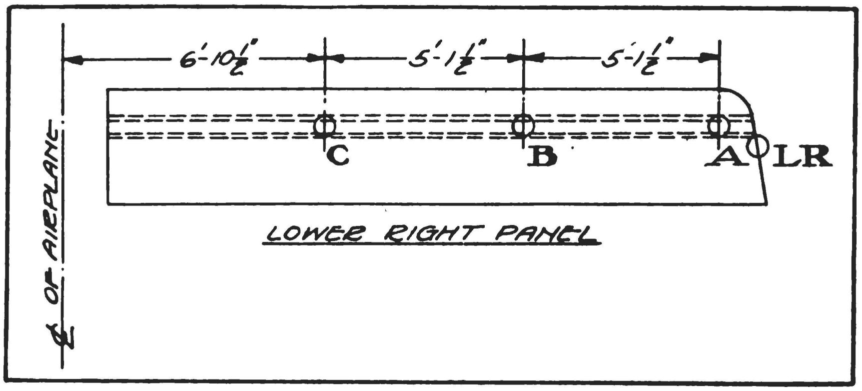


REVERSE LOADING.

LOADING SCHEDULE FOR UPPER AND LOWER WINGS.

Load factor.	Upper wing.			Total load.	Lower wing.			Total load.
	Front.	Middle.	Rear.		Front.	Middle.	Rear.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
2	221	111	111	4,430	79	39	39	1,570
2.5	282	142	141	5,660	100	50	50	2,000
3	343	173	171	6,870	121	61	61	2,430

Fig. 6.—Loading schedule—reversed flight.



REVERSE LOADING DEFLECTION OF LOWER WING SPAR.

Load factor.	Deflections in inches at—						Retreat—			
	A	B	C	D	E	F	LR	UR	LL	UL
2	1.8	1.3	1.1	1.2	1.5	2.0	+1.3	−.1	+ .9	−.3
2.5	2.3	1.1	1.5	1.7	2.1	2.9	+1.8	−.3	+1.2	−.4
3	2.8	2.1	1.9	2.2	2.7	3.6	+2.0	−.6	+1.7	−.3

FIG. 7.—Table of spar deflections

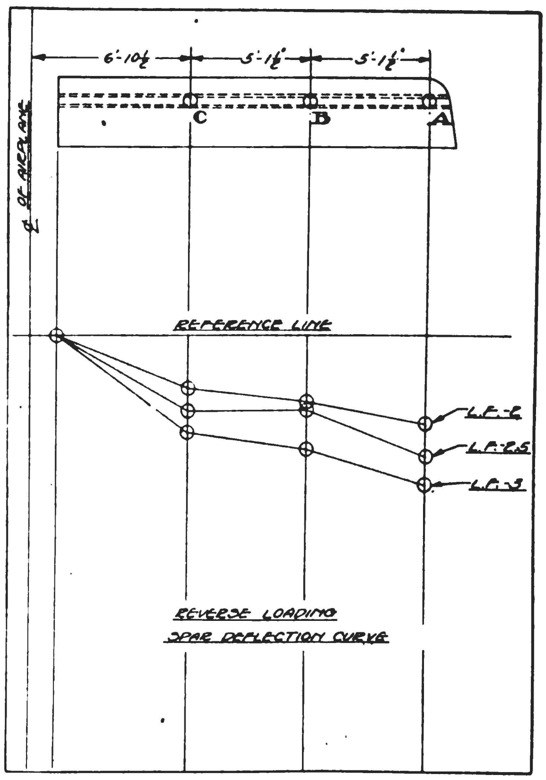
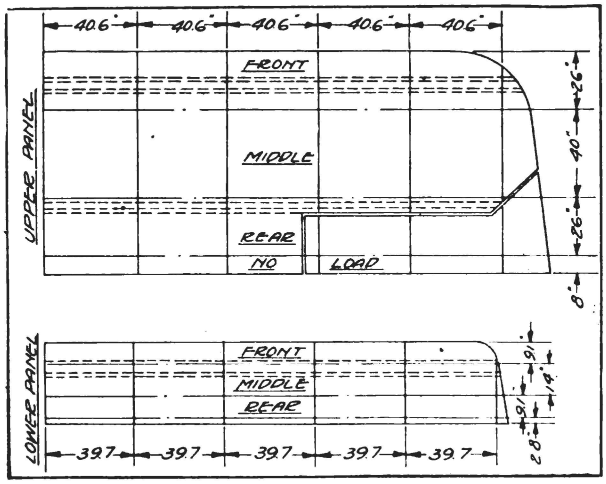


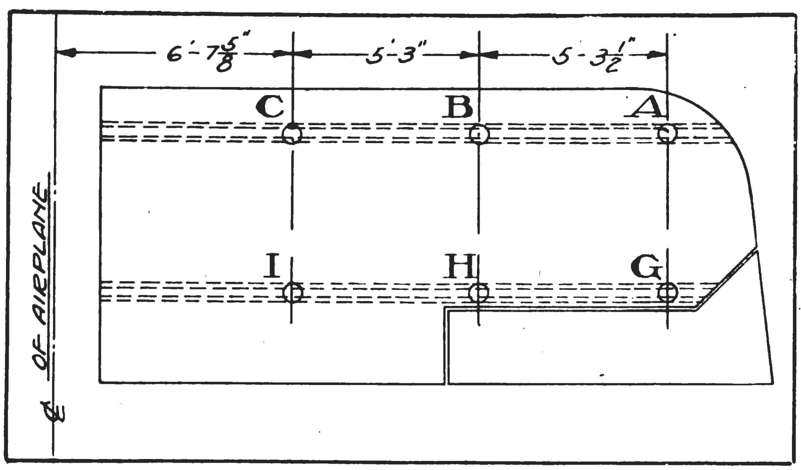
FIG. 8.—Chart showing deflection curves,



LOW INCIDENCE—LOADING SCHEDULE FOR UPPER AND LOWER WINGS.

Load factor.	Upper wing.			Total load.	Lower wing.			Total load.
	Front.	Middle.	Rear.		Front.	Middle.	Rear.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
2	142	284	142	5,680	91	181	91	3,630
2.5	167	335	167	6,690	107	213	107	4,270
3	192	386	192	7,700	123	245	123	4,910
3.5	217	437	217	9,710	139	277	139	5,480

FIG. 9.—Loading schedule—low incidence.



LOW INCIDENCE DEFLECTIONS OF SPARS OF UPPER WING.

Load factor.	Deflections in inches measured at—												Retreat.			
	A	B	C	D	E	F	G	H	I	J	K	L	UL	LL	UR	LR
3	2.1	1.3	0.9	0.9	1.2	1.7	2.9	2.1	1.6	1.7	2.1	3.0	+0.4	+2.1	+0.2	+1.8
3.5	1.7	1.2	.9	1.1	1.5	2.4	3.2	2.4	1.9	2.3	3.0	4.1	.7	2.6	.3	1.9
4	1.8	1.3	1.1	1.4	1.9	2.9	3.6	2.7	2.2	2.7	3.6	5.0	1.0	3.3	.4	2.5
4.5	2.1	1.6	1.4	1.6	2.0	3.0	4.1	3.1	2.8	3.2	4.0	5.8	1.1	3.9	−.2	3.0

FIG. 10.—Table of spar deflections.

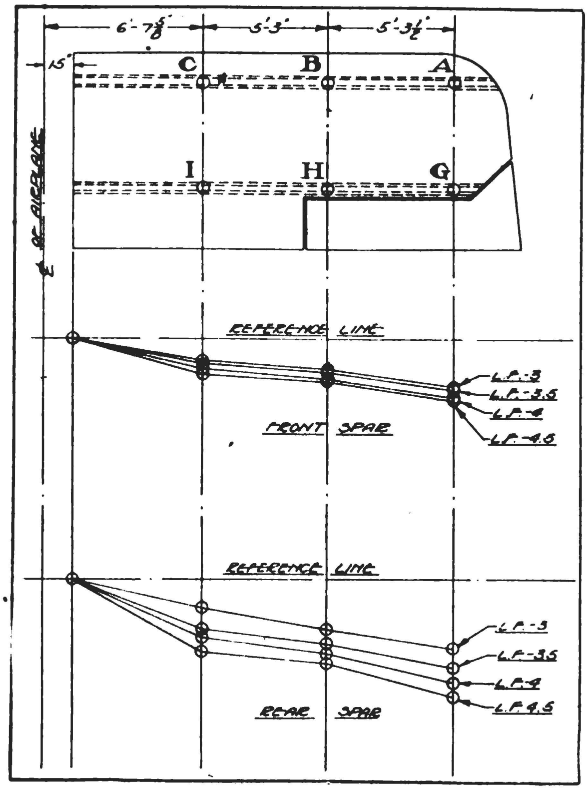
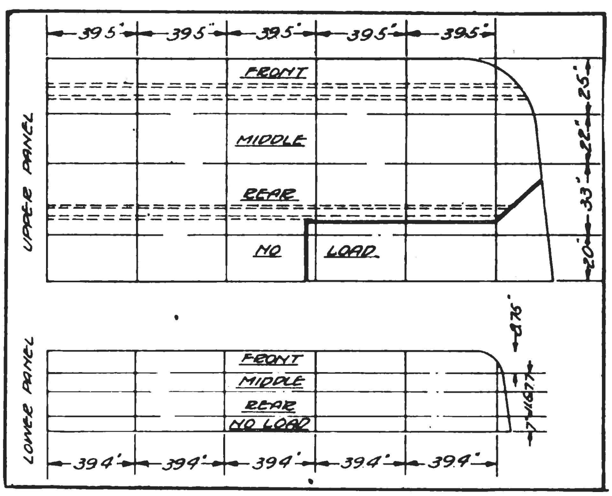


FIG. 11.—Chart showing deflection curves.



HIGH INCIDENCE LOADING SCHEDULE FOR UPPER AND LOWER WINGS.

Load factor.	Upper wing.			Total load.	Lower wing.			Total load.
	Front.	Middle.	Rear.		Front.	Middle.	Rear.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
3	326	163	163	6,520	140	70	70	2,800
4	442	221	221	8,840	189	95	85	3,790
5	558	279	279	11,160	238	120	120	4,780
5.5	615	308	308	12,310	262	133	133	5,280
6	672	337	337	13,460	286	146	146	5,780
6.5	729	366	366	14,610	310	159	159	6,280
7	786	395	395	15,760	334	172	172	6,780

FIG. 12.—Loading schedule—high incidence.

Strength properties of double wing beams from the PG-1 airplane.

Location of double beam.	Member of double wing beam.	Moisture content, per cent.	Specific gravity.	Modulus.		Fiber stress at elastic limit, pounds per square inch.	Compression parallel to grain, pounds per square inch.	Span in.
				Rupture, pounds per square inch.	Elasticity, 1,000 pounds per square inch.			
Right upper front.	Front..	7.80	0.375	[1] 11,280	1,560	[1] 8,065	6,985	36
	Rear...	7.84	.396	[1] 11,595	1,661	[1] 7,720	7,680	36
Right upper rear.	Intact..	......	......	[2] 7,250	1,700	4,655	......	102
	Front..	6.81	.400	[3] 7,090	1,800	6,180	6,950	102
	Rear...	7.44	.393	[4] 7,470	1,510	4,150	6,460	84
Right lower.	Intact..	......	......	9,170	1,782	6,570	......	60
	Front..	8.12	.431	8,460	1,965	5,970	7,500	60
	Rear...	8.58	.442	9,610	2,062	4,985	7,350	60

[1] The higher strength properties are due to the smaller test specimens used.
[2] Rear member brash.
[3] Horizontal shear failure.
[4] Spiral grain 1 : 14 and brash.

RECOMMENDATIONS.

More care should be exercised in the selection of wing beam material. The spar fittings and the compression tube with center section should be redesigned to support a load factor of 7.

AILERON.

DESCRIPTION.

The aileron is of wood construction with one main box spar. This spar is made of two spruce members routed so as to form a channel and joined together by three thirty-seconds 3-ply plywood.

The ribs are constructed with plywood webs and spruce cap strips.

Fabric is used for covering.

Figure 15 is a drawing of the aileron structure.

This aileron is of the balanced type, total area 21.21 square feet, area of balanced part 2.26 square feet.

PROCEDURE.

The aileron was loaded according to the loading schedule in Figure 16. The center of gravity of the load was located at five-twelfths of the chord from the hinge center, the load at the trailing edge being one-third the load at the hinge. A spring balance was connected to the control stick which registered the pull in the cables.

RESULTS.

First test.—At a load of 15 pounds per square foot the control stick deflected badly. The corresponding pull on the stick was 90 pounds. At a load of 20 pounds per square foot the ball joint on the end of the link connecting the control stick with the remainder of the control mechanism failed. Considerable crackling of the wing structure was noticed while the aileron was being tested.

Second test.—The aileron was loaded the second time and at a load of 20 pounds per square foot the aileron sagged badly. At a load of 22.5 pounds per square foot the bell crank, which is mounted in the wing structure, failed by twisting. The aileron structure showed no signs of failure.

Figure 17 is a table of the results of both aileron tests.

Figure 34 is a photograph of the ball joint failure.

Figure 35 is a photograph of the bell crank failure.

DISCUSSION.

While no weakness was manifest in the aileron structure during the test, the aileron controls failed before the required load was applied to the surface of the aileron, the required load being 25 pounds per square foot.

CONCLUSION.

The aileron structure is satisfactory structurally, but the controls and linkages thereof are weak.

RECOMMENDATIONS.

Redesign the aileron control system and the mounting of the bell crank in the wing structure so that the control system will stand a load of 25 pounds per square foot without failure.

ELEVATOR AND STABILIZER.

DESCRIPTION.

The elevator and stabilizer are of steel construction. The elevator is built up on a tubular steel spar and has formed sheet steel ribs which are welded together at the seams and riveted to the spar fittings.

The stabilizer main spar is built up of formed sheet steel members welded at the seams. The ribs are made in a similar way. The leading edge is a piece of steel tubing, to which the ribs are joined at their forward ends.

Area of elevators, 20.6 sq. ft., weight=26 lbs.; lbs. per sq. ft., 1.26 lbs.

Area of stabilizers, 30.6 sq. ft., weight=36 lbs.; lbs. per sq. ft., 1.17 lbs.

Figure 18 is a drawing of the elevator structure.

Figure 19 is a drawing of the stabilizer structure.

Figure 20 shows typical sections.

PROCEDURE.

The elevator and stabilizer were mounted on the fuselage and loaded according to the loading schedule in Figure 21. The required load for the elevator and stabilizer was 30 lbs. per sq. ft.

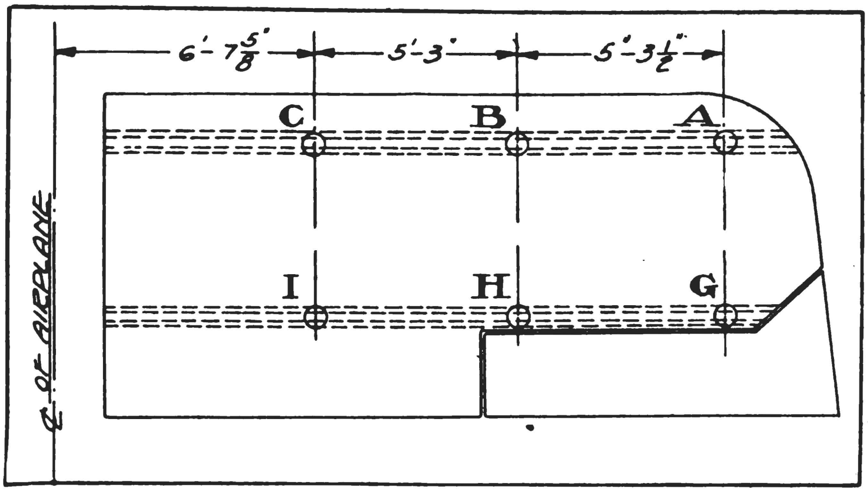
The surfaces were loaded in the ratio of 0.758 on the elevator to 1.137 on the stabilizer.

The center of gravity of the load on the elevator was located at five-twelfths of the chord from the center line of the hinge, the load at the trailing edge being one-third the load at the hinge.

RESULTS.

The first failure was the buckling of the rear spar of the stabilizer at a load of 20 pounds per square foot. The right side collapsed. The test was continued on the left side of stabilizer and at 27.5 pounds per square foot failure occurred.

The elevator and the controls are satisfactory structurally.



HIGH INCIDENCE DEFLECTIONS OF SPARS OF UPPER WING.

Load factor.	Deflections in inches measured at—												Retreat.			
	A	B	C	D	E	F	G	H	I	J	K	L	UL	LL	UR	LR
3	1.9	1.4	1.2	1.2	1.5	2.2	1.2	0.9	0.9	0.9	0.9	1.3	+.2	− .4	−0.5	+ .2
4	1.9	1.9	1.7	1.8	3.6	3.1	1.6	1.2	1.2	1.2	1.3	1.6	.3	− .6	−0.3	+1.1
5	2.9	2.3	2.1	2.4	4.5	4.5	1.7	1.3	1.4	1.5	1.7	2.4	.4	− .8	−0.6	−2.1
5.5	3.4	2.6	2.4	2.8	4.5	4.9	1.9	1.5	1.6	1.7	2.0	2.6	.5	−1.0	−0.7	−2.5
6	3.8	3.1	2.8	3.1	4.5	5.6	2.2	1.7	1.8	1.9	2.0	2.8	.3	−1.2	−0.7	−3.0
6.5	Failure.															
7	Required load factor.															

NOTE.—At a load factor of 5 the upper spar center section compression tube deflected $\frac{1}{16}$", at A. L. F. of 6 the tube deflected $\frac{1}{8}$" and had to be reinforced with wood members to prevent failure.

FIG. 13.—Table of spar deflections.

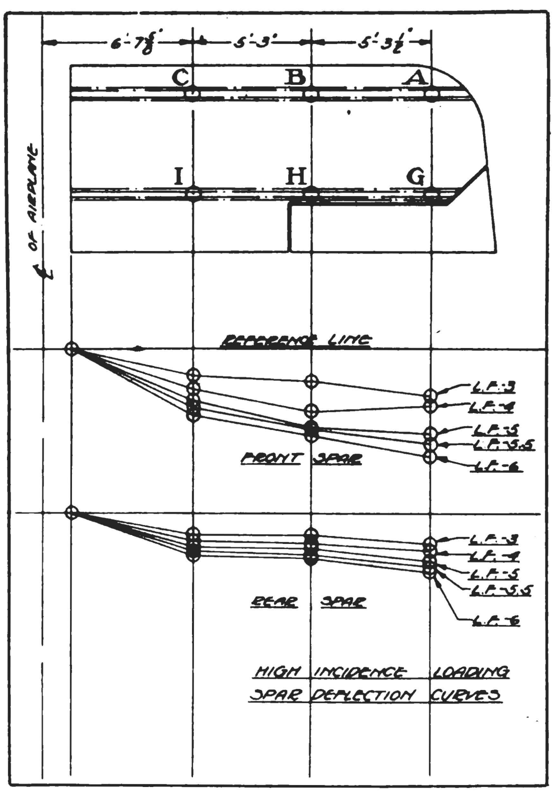


FIG. 14.—Chart showing deflection curves.

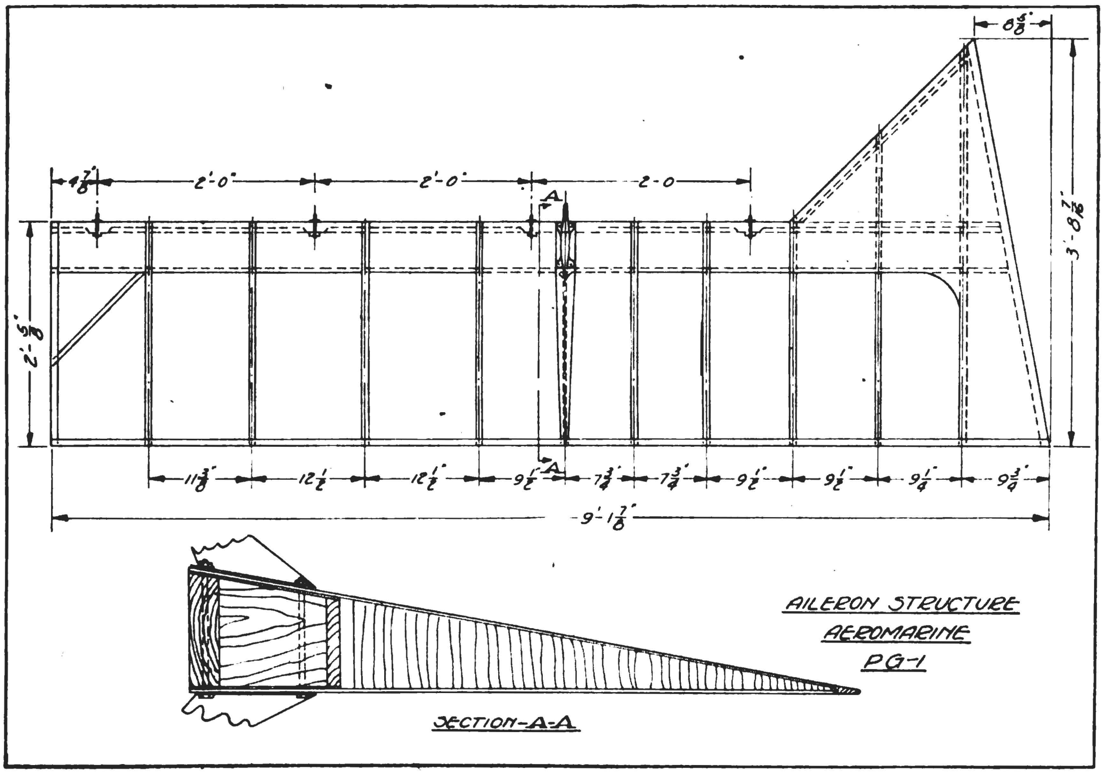
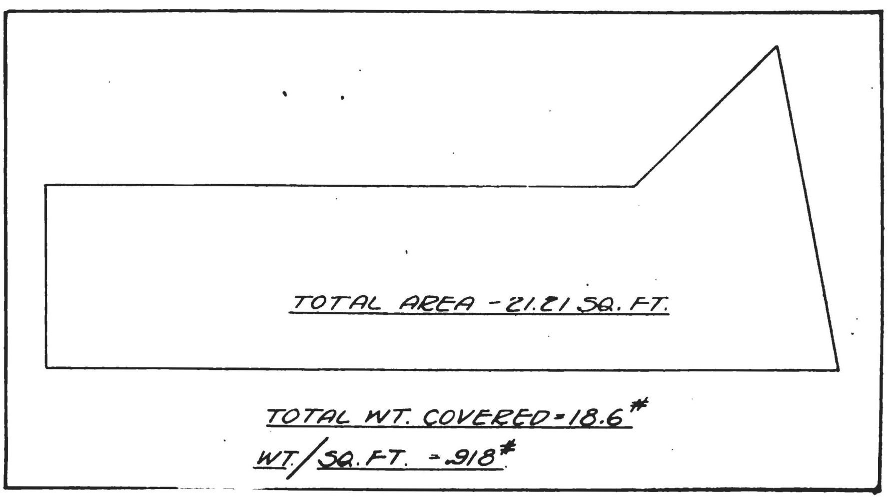


FIG. 15.—Aileron structure.



AILERON LOADING SCHEDULE.

Lbs./ sq. ft.	Load on aileron proper.	Load on balanced part.	Total load on surface.	Lbs./ sq. ft.	Load on aileron proper.	Load on balanced part.	Total load on surface.
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
5	90	16	106	20	360	64	424
10	180	32	212	22.5	405	72	477
15	270	48	318	25	450	80	530

FIG. 16.—Aileron loading schedule.

Results of aileron tests.

FIRST TEST.

Pounds per square foot.	Pull on stick.	Remarks.
	Pounds.	
5	25	
10	55	
15	90	Control stick deflecting badly.
20	....	Failure of ball joint on link connecting control stick with crank on vertical tube.
22.5	....	
25	....	Required loading.

SECOND TEST.

5	(1)	
10	(1)	
15	(1)	
20	(1)	Aileron sagging badly.
22.5	(1)	Failure of bell crank mounted in wing cell. This failure was due to eccentric loading.
25	(1)	

[1] Failure of ball joint eliminated control stick; pull could not be registered.

FIG. 17.—Table of aileron results.

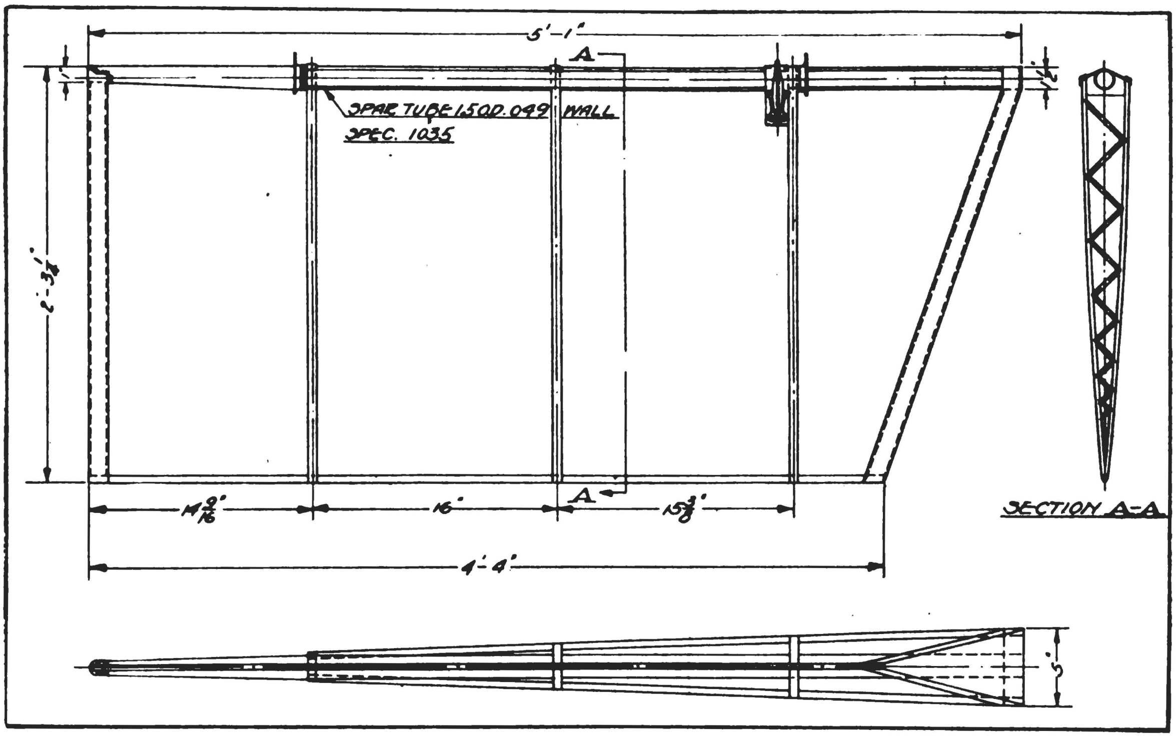


FIG. 18.—Elevator structure.

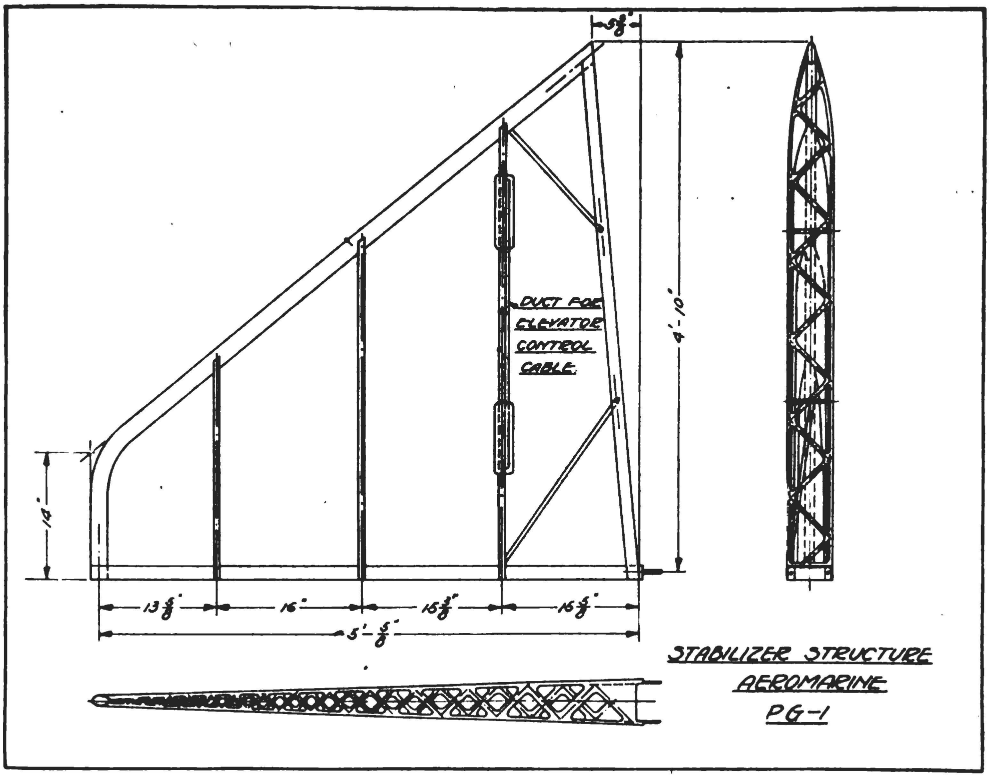


FIG. 19.—Stabilizer structure.

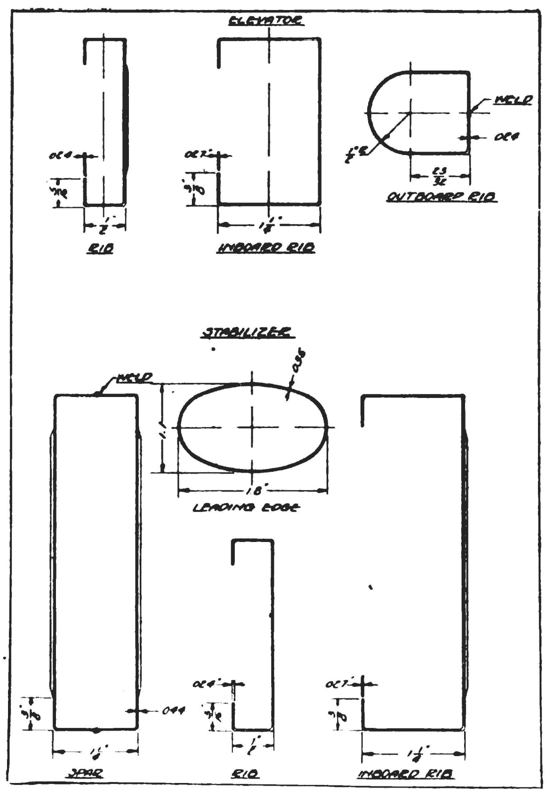
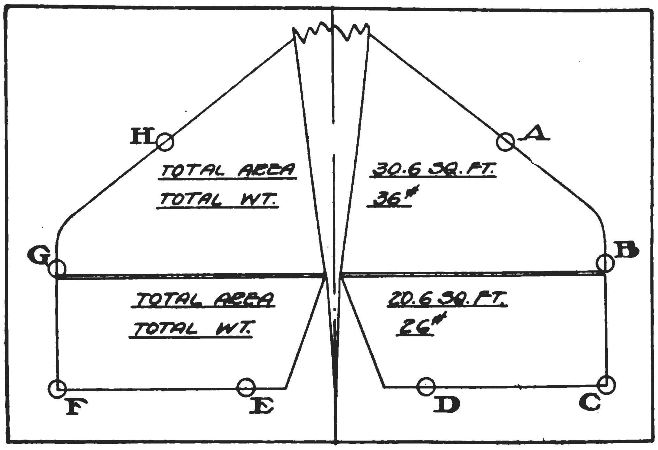


FIG. 20.—Typical section of elevator and stabilizer.



LOADING SCHEDULE AND RESULTS OF ELEVATOR AND STABILIZER TEST.

Pounds per square foot.	Load on elev.	Load on stab.	Total load.	Pull on stick.	Deflections in inches at—							
					A	B	C	D	E	F	G	H
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*								
5	82	174	256	30	0.3	0.5	1.7	1.3	1.2	1.4	0.1	0.2
10	164	348	512	60	.5	3.6	3.0	2.5	1.7	3.3	.5	.5
15	246	522	768	95	.9	5.6	4.8	3.8	4.4	5.4	.9	.9
20	328	696	1,024	....	First failure.				8.4	12.9	5.5	4.2
22.5	369	783	1,152	....	Deflections discontinued.							
25	410	810	1,280	....	....	....	....	....	....	....	....	....
27.5	451	957	1,408	....	Second failure.				....	....	....	....
30	492	1,044	1,436	....	....	....	....	....	....	....	....	....

First failure at loading of 20 pounds per square foot right rear stabilizer spar buckled between first and second rib from fuselage.

Second failure at loading of 27.5 pounds per square foot left rear stabilizer spar.

FIG. 21.—Loading schedule and results of test.

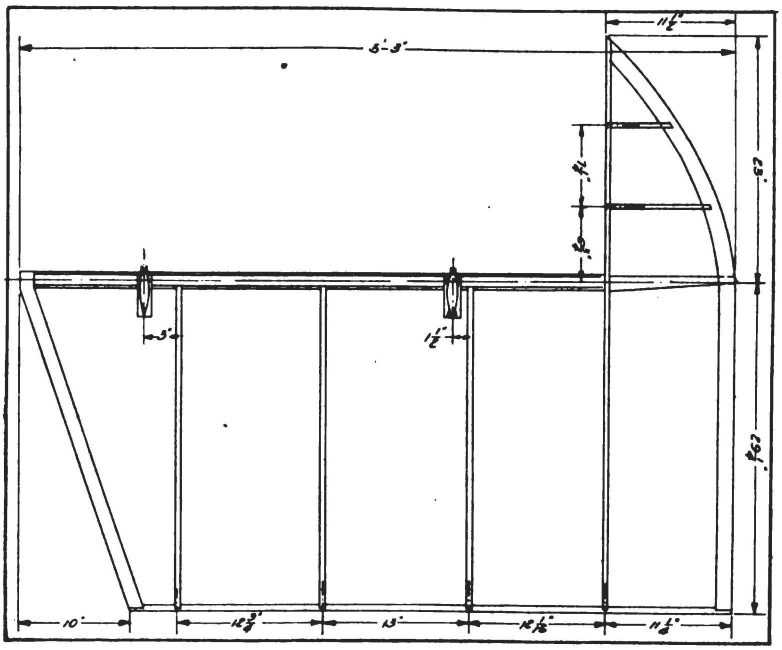


FIG. 22.—Rudder structure.

Figure 21 gives the deflections and results of the test.

Figure 36 is a photograph of the failure of the right side of the stabilizer spar.

Figure 37 is a photograph of both right and left spar failures.

DISCUSSION.

By the use of two external braces the stabilizer structure could be made to support the required load, but if it is desired to do away with all external brace members on the tail surfaces, the rear stabilizer spar must be made heavier.

CONCLUSION.

The rear spar of the stabilizer is weak.

RECOMMENDATIONS.

Redesign the rear spar of stabilizer to support the required loading of 30 pounds per square foot on the horizontal tail surfaces, or add external brace members.

RUDDER AND FIN.

DESCRIPTION.

The rudder and fin are both of steel construction.

The rudder is built on a steel tubular spar with ribs of formed sheet steel welded at the joints and riveted at the fittings. The trailing edge is an eliptical tube bent to shape and welded to the ribs, the ribs being welded to main spar. The rudder is of the balanced type and is covered with fabric.

The fin is built of formed steel members and tubes welded at the joints. The main frame and leading edge is formed sheet steel, while the brace members are steel tubes. The rudder hinges are brazed to the frame.

Fabric is used for covering.

The following is a table of areas:

	Area.	Weight.	Weight per square foot
	Square feet.	*Pounds.*	*Pounds.*
Rudder	13.33	15.5	1.16
Balanced part	1.00		
Fin	6.53	8.43	1.29

Figure 22 is a drawing of rudder structure.

Figure 23 is a drawing of fin structure.

Figure 24 shows typical sections.

PROCEDURE.

The rudder and fin were assembled on the fuselage and the fuselage turned on its side and properly supported. A spring balance was attached to the rudder pedal to register the pull in the controls.

The center of gravity of the load on the rudder was located at five-twelths of the chord from the hinge center, the load at the trailing edge being one-third the load at the hinge center.

The surfaces were loaded according to the loading schedule in Figure 25.

The required load was 25 pounds per square foot.

RESULTS.

The results and deflections are tabulated in Figure 25. The rudder and fin are satisfactory structurally, having supported a load of 27.5 pounds per square foot. The rudder pedal started to twist at a load of 15 pounds per square foot.

CONCLUSION.

The rudder and fin are satisfactory structurally, but the rudder pedals showed too much torsional deflection.

RECOMMENDATIONS.

The rudder pedals should be redesigned to stand a load of 25 pounds per square foot on the rudder.

FUSELAGE.

DESCRIPTION.

The entire fuselage is of steel construction, the forward part being armored with three-sixteenths armor plate. The rear portion of the fuselage is of conventional design with steel tube longerons and steel tube brace members.

Figure 26 is a drawing of the fuselage showing plan and side views.

PROCEDURE.

The fuselage was supported on a jig and loaded as per loading schedule, figure 27.

Due to the fact that the forward portion of the fuselage structure is composed of armor plate, the only possible chance of failure was to the rear of the armored portion. The load on the armored part acted merely as a counterbalance for the tail load.

RESULTS.

The deflections and results are shown in Figure 29. The required load factor was 6. The structure supported a load factor of 6.5 and then failed in first bay to rear of the armor plate. The lower longerons failed in compression.

DISCUSSION.

The first failure was the left lower longeron, which failed when the fabric was cut. The tube was drawn back to place by blocks and clamps and a load factor of 7 was imposed. The fabric on the right side was then cut and failure of right longeron followed.

Figure 38 is a photograph of lower longeron failures.

CONCLUSION.

The fuselage is satisfactory structurally.

LANDING CHASSIS.

DESCRIPTION.

The landing chassis is a two strut type chassis with wood struts and sheet steel fittings at the bottom to take the shock absorber. There is a tubular steel axle and horizontal brace members. Double flexible diagonal brace wires are used.

Figure 29 is a drawing of the chassis.

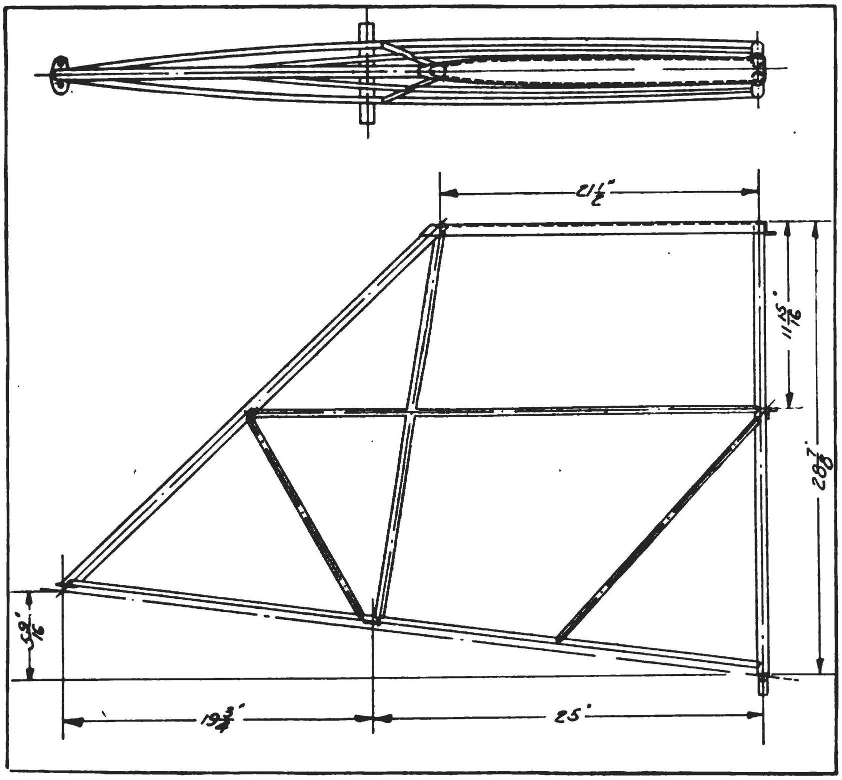


Fig. 23.—Fin structure.

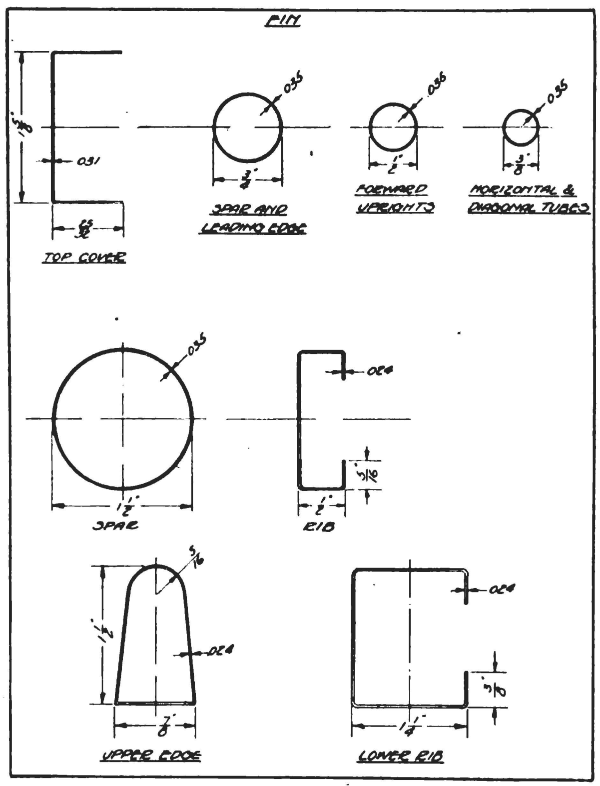
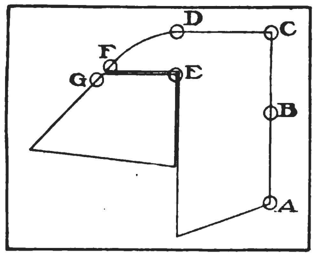


Fig. 24.—Typical sections of fin and rudder.



Area of rudder, 13.33 square feet. Weight = 15.5 pounds.
Area of fin, 6.53 square feet. Weight = 8.43 pounds.

LOADING SCHEDULE AND RESULTS OF RUDDER AND FIN TEST.

Pounds per square foot.	Load on bal. part.	Load on rudder proper.	Load on fin.	Total load on surfaces.	Pull on stick.	Deflections in inches at—						
						A	B	C	D	E	F	G
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*							
5	6	52	40	96	55	.3	0	0	.4	.1	1.3	.1
10	12	104	82	198	95	1.0	0	0	.5	.3	.9	.2
15	18	156	120	294	155	1.5	.7	1.0	.9	.5	.8	.2
20	24	208	164	396	230	1.4	.9	1.4	1.2	.8	1.1	.4
22.5	27	234	185	446	285	1.6	1.1	1.8	1.5	.9	1.1	.4
25	30	260	206	496	305	2.2	1.8	2.6	1.7	1.0	.8	.5
27.5	33	286	227	348		Held required loading.						

Rudder pedal started twisting when average loading was 15 pounds per square foot. At a loading of 27.5 pounds per square foot the deflection of rudder pedal was ½ inch.

FIG. 25.—Loading schedule and results for rudder and fin.

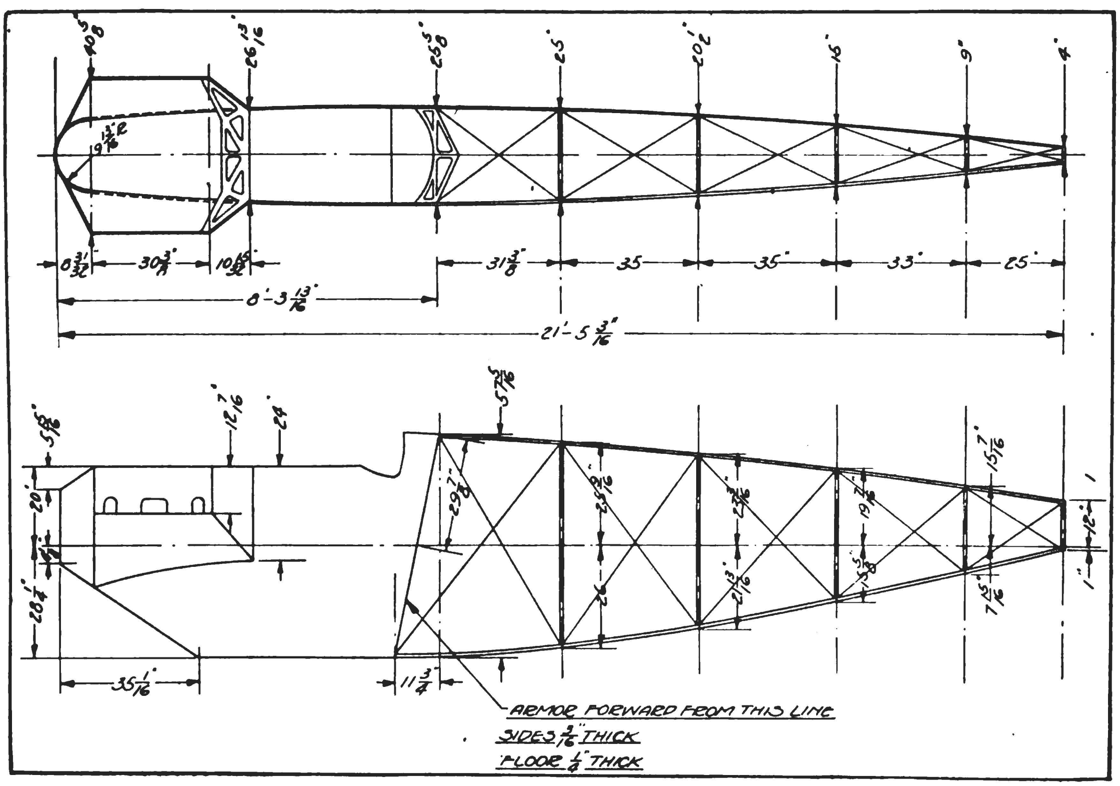
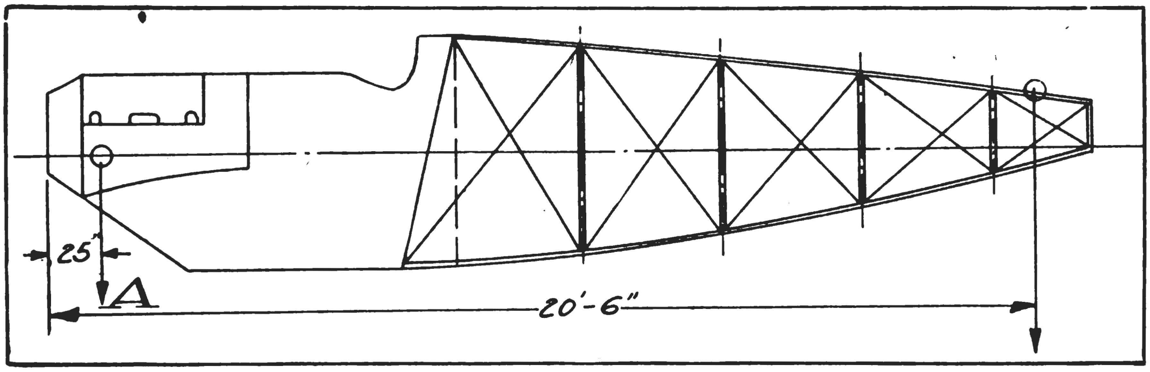


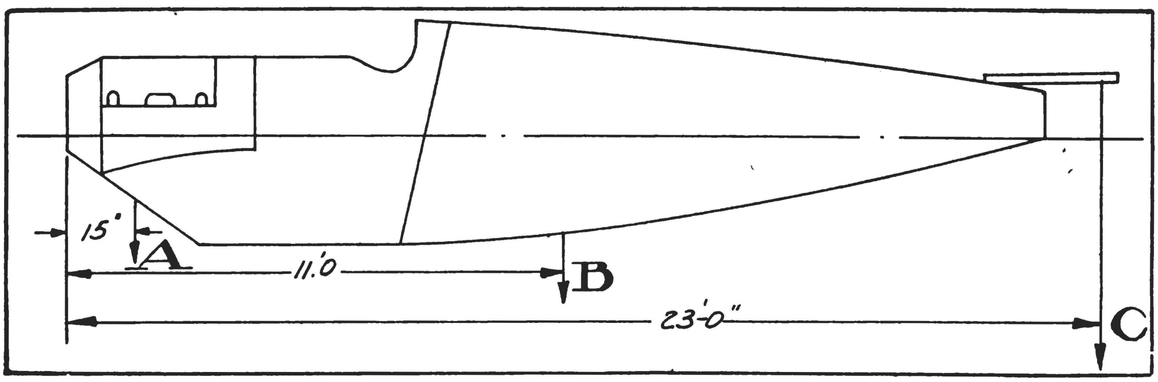
FIG. 26.—Plan and side view of fuselage.



FUSELAGE LOADING SCHEDULE.

Load factor.	Engine load.	Tail load.	Total load.	Load factor.	Engine load.	Tail load.	Total load.
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
2	2,120	733	2,853	5.5	5,830	2,105	7,935
3	3,180	1,125	4,305	6	6,360	2,301	8,661
4	4,240	1,517	5,757	6.5	6,890	2,497	9,387
5	5,300	1,909	7,209	7	7,420	2,693	10,113

FIG. 27.—Loading schedule for fuselage.



DEFLECTIONS AND RESULTS OF FUSELAGE TEST.

Load factor.	Deflections at—			Remarks.
	A	B	C	
2	0	.2	.7	
3	0	.3	1.0	
4	−.1	.3	1.1	
5	−.1	.4	1.6	
5.5	−.1	.4	1.8	
6	−.2	.5	2.0	
6.5	....	....	....	Failure of left lower longeron after fabric was cut, this longeron was
7	....	....	....	reinforced and right lower longeron failed a factor of 7.

FIG. 28.—Deflections and results of fuselage test.

PROCEDURE.

The landing chassis was mounted in the test jig and loaded per loading schedule in Figure 30.

The chassis was mounted in such a way that the center of gravity of the load came vertically over the center of the axle. The shock absorber elastic was not wound evenly on both sides and had to be removed at a load factor of 3, and replaced by a steel cable.

RESULTS.

The right shock absorber fitting failed at a load factor of 5. The two five-sixteenths bolts sheared off while the center three-eighths inch bolt on the lower side pulled entirely through the fitting.

Figure 39 is a photograph of the failure.

CONCLUSION.

The required load factor for the struts is 6. The struts and axle are strong enough, but the shock absorber fittings are weak.

RECOMMENDATIONS.

Strengthen the shock-absorber fittings where failures occurred. These fittings should be redesigned to stand a load factor of 6, the required factor for the struts.

LEADING EDGE TEST.

DESCRIPTION OF SET-UP.

A 6-foot section was cut from the upper wing panel and mounted on a framework so that the main points of support were along the wing spars.

A counterbalance of lead shot bags was placed on the rear portion of the wing section to counterbalance the load placed on the leading edge.

The leading edge was then loaded in increments of 100 pounds and, as signs of failure were noticed, 50 pounds increments were added.

RESULTS.

When a load of 3,450 pounds was allowed to remain on for 1 minute, the leading edge sheared off.

Figure 31 shows the method of support and gives the computations.

CONCLUSION.

Since the failure occurred at a load factor of 16.3, the leading edge is amply strong.

TAIL SKID TEST.

DESCRIPTION.

The fuselage was attached at the front end to a jig and a load of 500 pounds placed and secured on the fuselage just over the tail skid. The fuselage was inclined to the left at an angle of 14° from the perpendicular. The rear portion of the fuselage was so coupled to a hoist that it could be raised and dropped suddenly.

PROCEDURE.

The tail skid withstood the first and second drop of 6 inches and 12 inches, respectively, without failure.

On the 18-inch drop one small crack was noticed on the tail skid and the fuselage twisted somewhat.

On being dropped 24 inches the tail skid and rear portion of fuselage both collapsed.

Figure 40 is a photograph of the failure.

DISCUSSION.

Even though the shock-absorber elastic functioned properly, the tail skid itself is too weak to stand the shock imposed upon it. The rear end of the fuselage is also very weak and not strong enough to withstand the torsion imposed by this particular test.

The required distance a tail skid must be able to drop without failure is 36 inches.

CONCLUSION.

The tail skid and rear of fuselage are both weak. The fuselage is too narrow to resist the torsion.

RECOMMENDATIONS.

Redesign tail skid, shock absorber, and rear of fuselage to withstand a 36-inch drop.

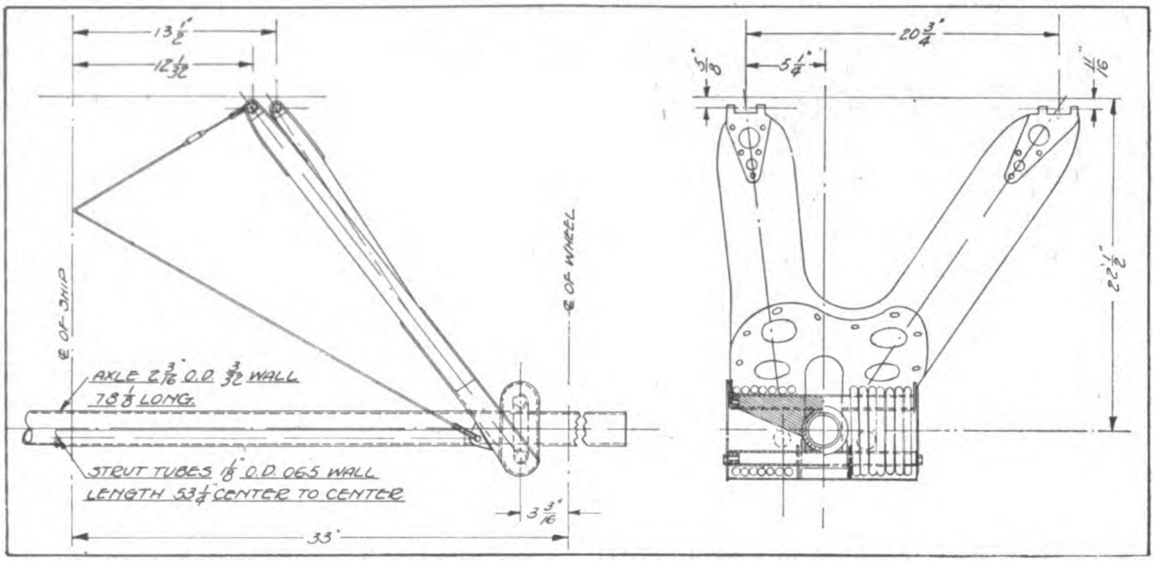
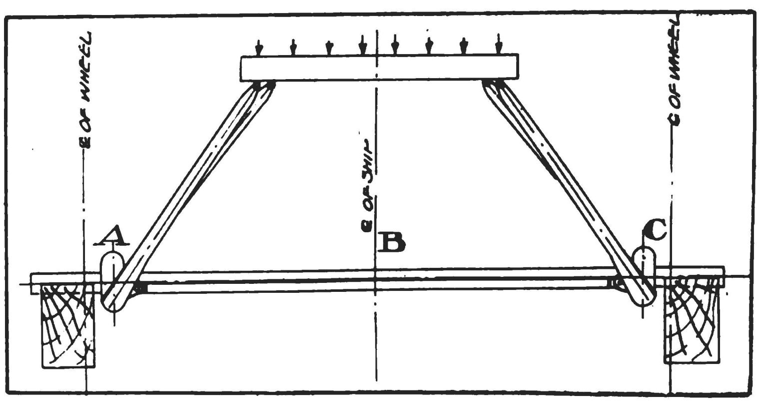


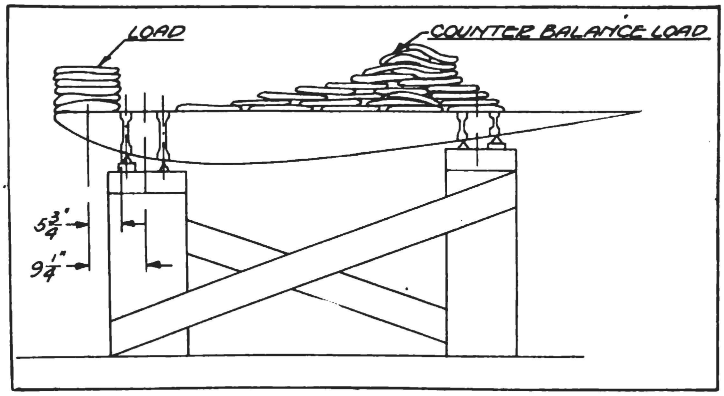
FIG. 29.—Landing chassis.



DEFLECTIONS AND RESULTS OF LANDING CHASSIS TEST.

Load factor.	Deflections at—			Load in pounds, factor.	Total load (pounds).	Remarks.
	A	B	C			
2	$1\frac{3}{8}$	$\frac{7}{16}$	$1\frac{3}{32}''$	6,641	6,641	
3	....	$\frac{3}{4}$	....	3,918	10,559	Shock absorber chords removed.
4	....	$\frac{11}{16}$	....	3,918	14,447	Held.
4.5	....	....	....	1,959	16,436	Struts on right-hand side sinking into fitting, strut deflecting, axle $\frac{1}{16}''$ set.
5	....	....	....	1,959	18,395	Failure of $\frac{5}{16}''$ bolts on right-hand side.
5.5	....	....	....	1,959	....	
6	....	....	....	1,959	....	Required factor.

FIG. 30.—Loading schedule and deflections for landing chassis.



TEST DATA.

The leading edge was loaded in accordance with the above sketch.
The load was increased until the total load on the leading edge was 3,450 pounds.
The structure supported this load for one minute when the failure occurred.
The leading edge sheared off at the face of the front spar.
Load for factor of 1=3,308 pounds load carried by upper wing 3,308×.7=2,315.6 pounds.
Load per foot run=2,315.6÷32,875=70.43 pounds.
Load for factor of 1 on leading edge=70.43÷2=35.21 pounds.
Load on leading edge causing failure=3,450 pounds.
3,450÷6=575 pounds=load per foot run causing failure.
$\frac{575}{35.21}$=16.32 factor at which leading edge failed.

FIG. 31.—Leading edge of wing test.

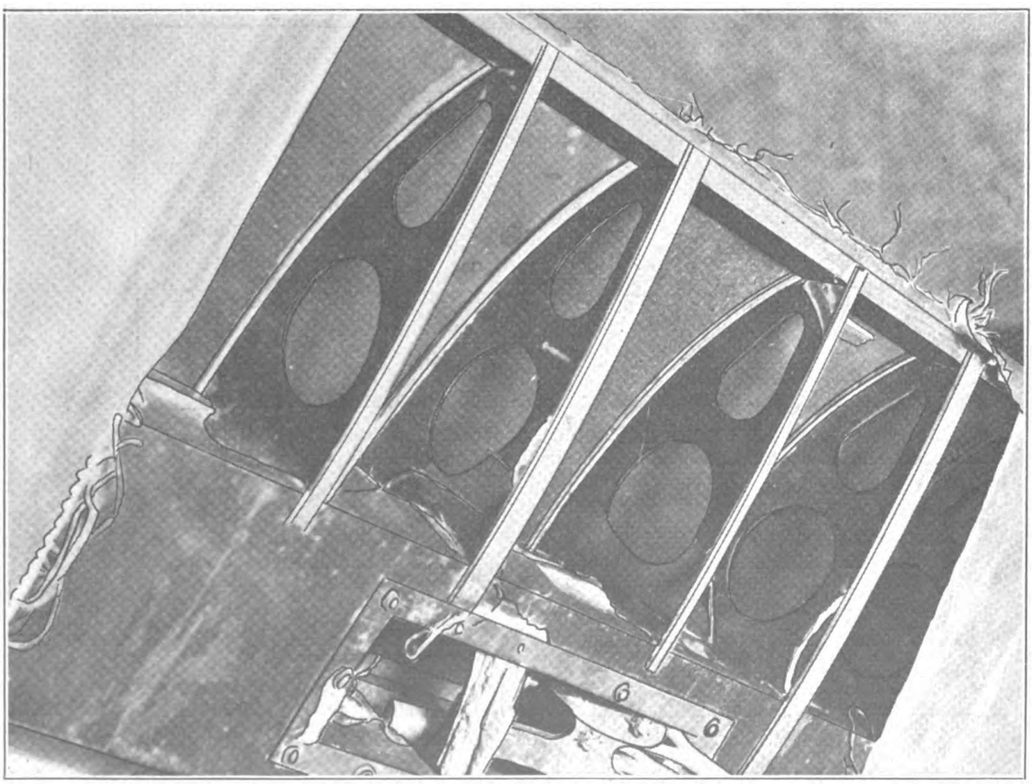


FIG. 32.—Spar and compression tube failure.

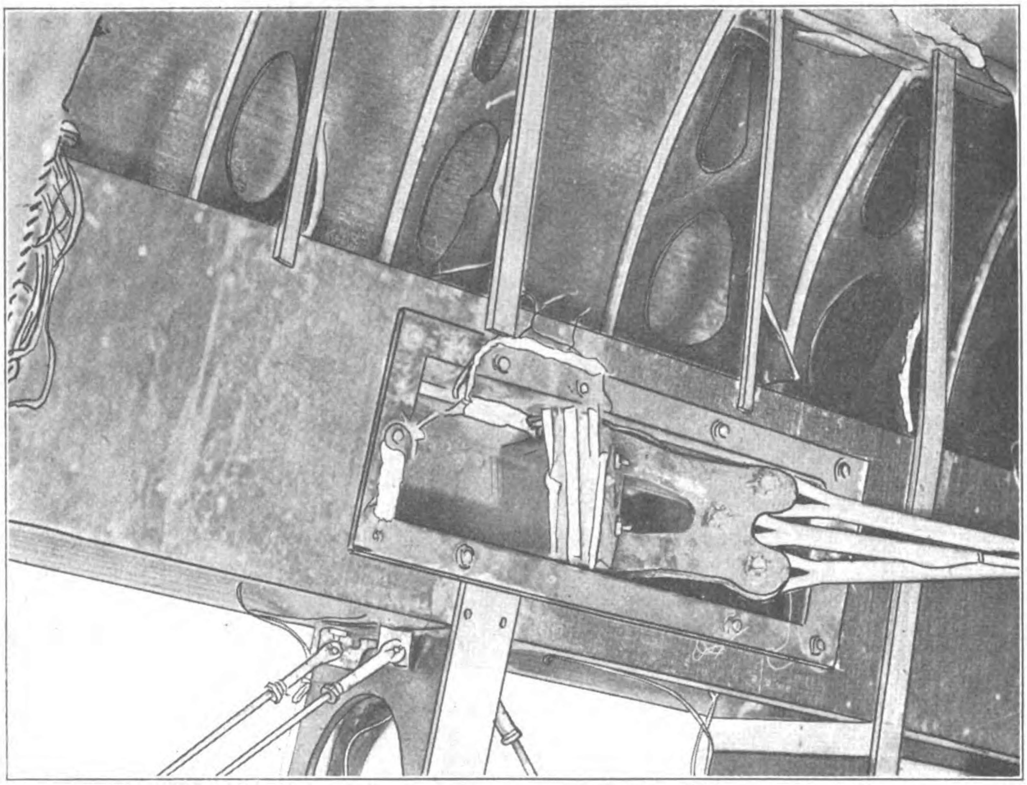


FIG. 33.—Spar and compression tube failure.

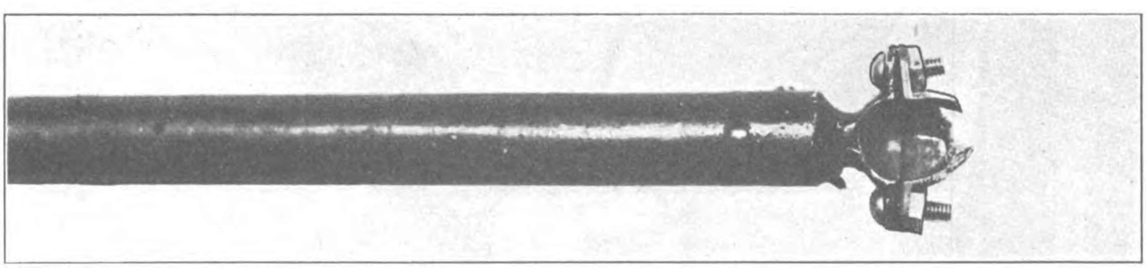


FIG. 34.—Ball joint failure

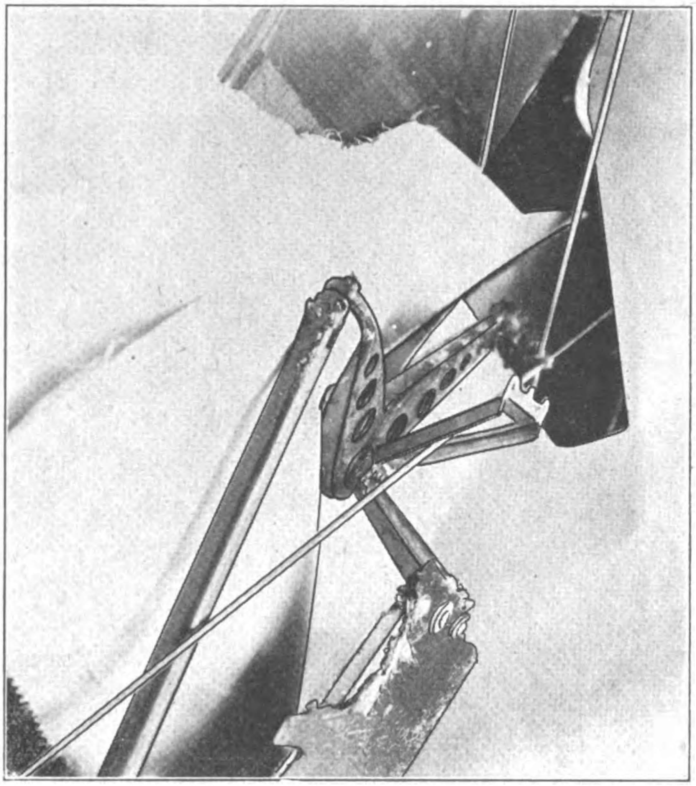


FIG. 35.—Ball crank failure.

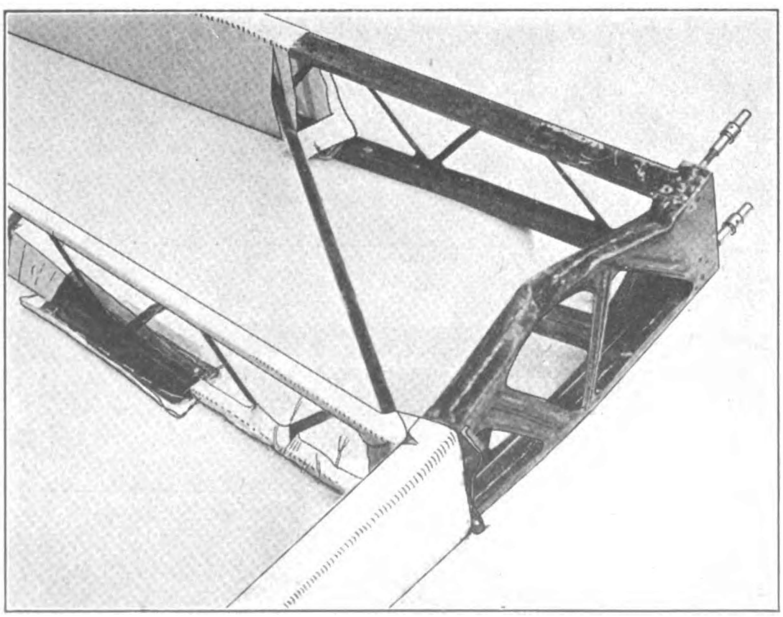


FIG. 36.—Failure of right stabilizer spar.

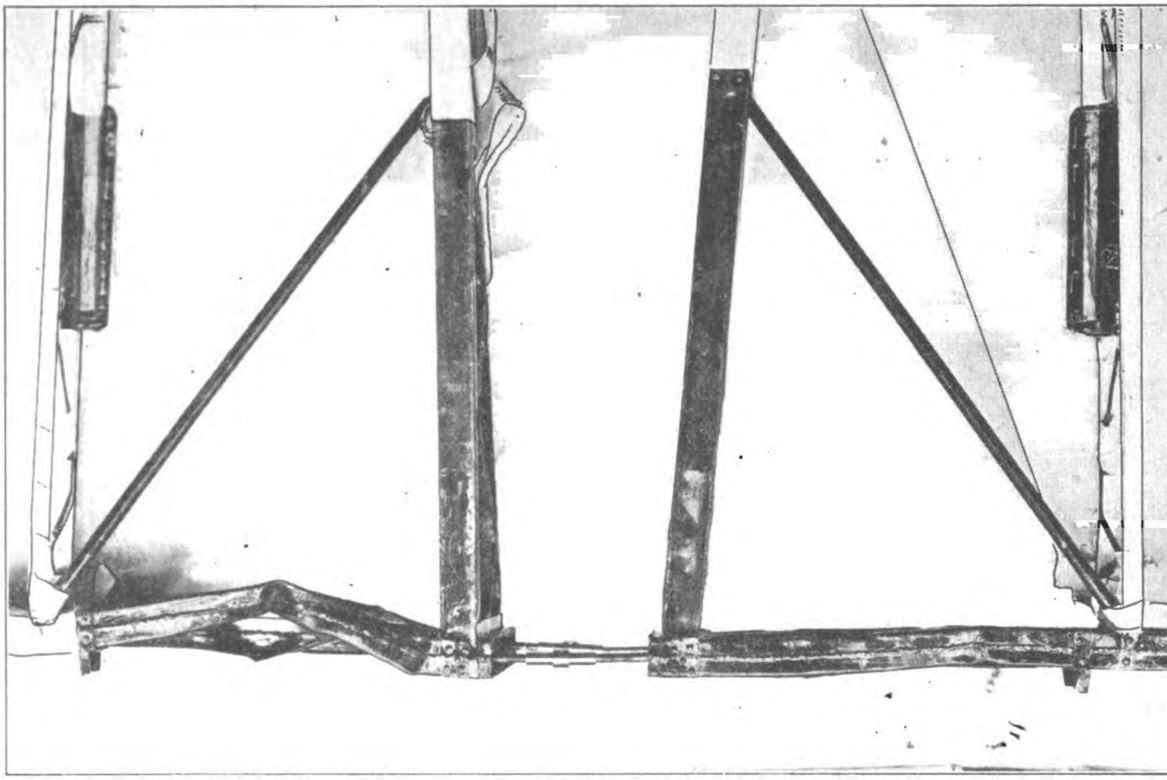


FIG. 37.—Failure of right and left stabilizer spars.

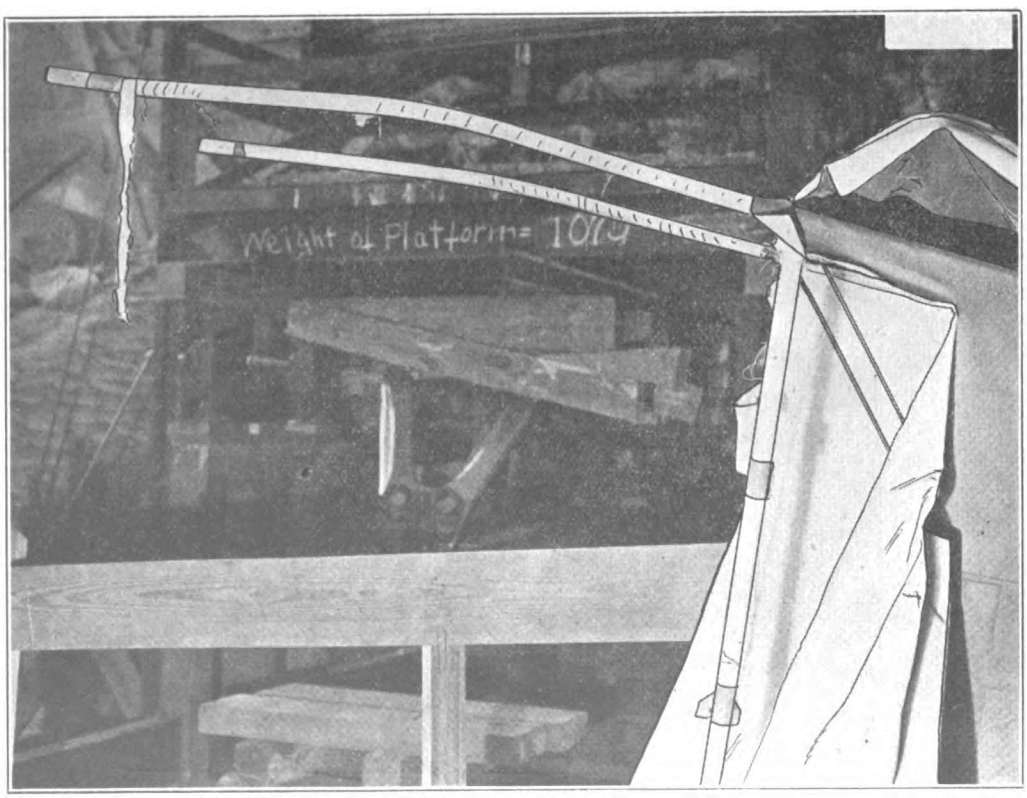


FIG. 38.—Lower longeron failure.

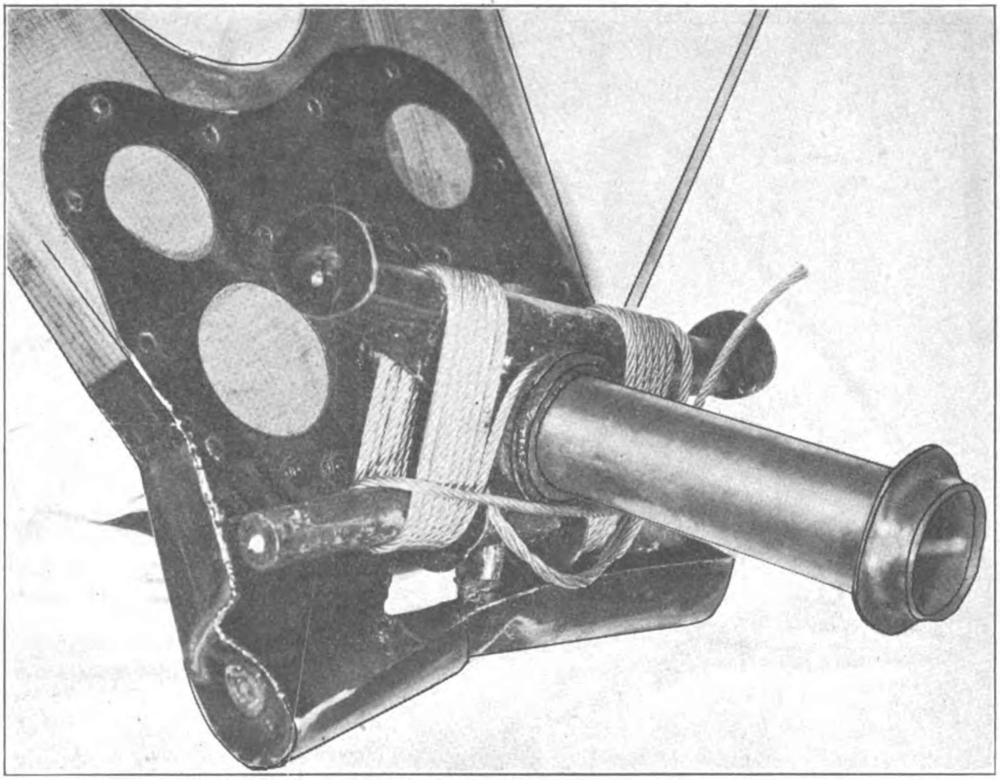


FIG. 39.—Landing gear failure.

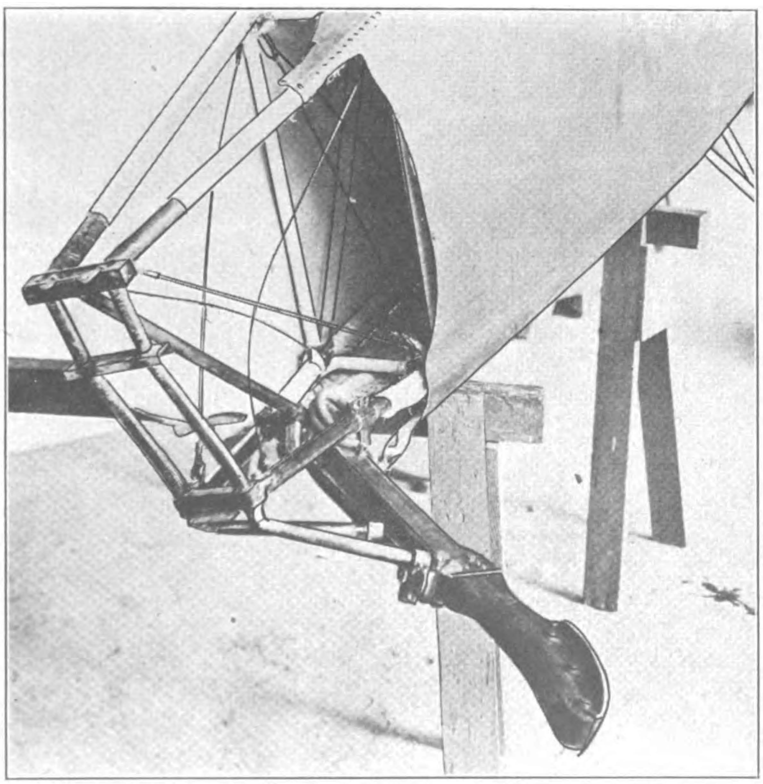


FIG. 40.—Tail skid failure.